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An electronic irrigation system using IoT and neural networks

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ABSTRACT

One of the approaches that fall under the alternative application of water on earth or soil is electronic irrigation. It is aware of the need to irrigate crops, restore the vegetation of difficult soil in arid areas, and because of dry spells, as our state has experienced in recent years. Other issues, such as increasing plant growth while lowering the value of agriculture, necessitate installing an irrigation system that cuts back effort, reduces farm and field employees, and minimizes monetary matters within the construction of agricultural comes is crucial. Soil wetness measure is incredibly tough; thus the economic maintaining of its target levels. The answer to this drawback is an automatic irrigation system. This analysis proposed an electronic irrigation system that reduces users' effort to plant care. The system kernel is the self-learning Kohonen Neural Network, which depends on the reading of the detector of soil wetness, plant type, and forecast data. The soil wetness detector indicates the soil wetness level. Also, the system is mechanically started once the wetness level is not up to the extent necessary for the plant's growth. When the system reaches the soil wetness level, it is mechanically stopped for a defined period of morning and evening. As a soil wetness level differs from one plant kind to a different, 3 plant varieties area unit used during this analysis. Beginning the system littered with the weather data, is saving time and effort for the employees.

Keywords: Electronic Irrigation, ANN, IOT, Wastewater Reduction, Soil Moisture Measurement, Self-Learning System, SOM algorithms

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1. Introduction

Water is precious, especially in areas where rainfall is scarce. Smart irrigation is the equivalent of plentiful harvests at a low cost. These farmers are the first to implement an intelligent irrigation system that calculates the amount of water required by the soil based on the moisture content. An intelligent irrigation system calculates the amount of water the land need. It can also be used to determine crop irrigation requirements based on seasons and crop type. This is accomplished through the use of sensors embedded in the soil. If the land is dry and requires water, it automatically irrigates the crops. [1–3]. One of the most environmentally beneficial systems is intelligent watering plants [4–6]. If preliminary tests show that more than two-thirds of the water required for watering can be given, it intends to protect water wealth. The economic impact of reducing costs and expenses in agricultural projects by reducing work force, using remote irrigation without needing to be in the irrigated area [7, 8].
The system is low-cost, based on low-cost hardware, and a farmer may control it using a smartphone or computer. This necessitates sensors of the soil moisture sensor placed beneath the soil, a card Ardunio card type mega, and a water pump linked to the Ardunio card to deliver water to the solid that requires irrigation. Finally, a computer is necessary to computerize the system's control [9–11]. When heavy metals are exposed to less

watering, they tend to go to the soil away from the dropper. While minerals are transported in considerable quantities in the soil on the subsurface surface by irrigation, these findings suggest that drip irrigation is greatly influenced by the distribution and concentration of heavy metals in soil, and irrigation uses less water than irrigation. As a result, heavy metals' horizontal migration is influenced, and larger quantities impact their vertical movement. [12–15].

2. Irrigation methods

Farmers irrigate their crops in various ways, depending on their demands. From manually watering individual plants to automated irrigation using a rotation system, Table 1 shows water requirements for some selected crops. These approaches, on the other hand, can be divided into five groups based on how they wet the soil:

Table 1. Water requirements for some selected crops

Crop	Water needs (mm/period)	Sensitivity to water supply (ky)	Water utilization efficiency for harvested yield, Ey, kg/m3 (% moisture)
Alfalfa	800-1600	low to medium-high (0.7-1.1)	1.5-2.0 hay (10-15%)
Banana	1200-2200	High (1.2-1.35)	Plant crop: 2.5-4 ratoon: 3.5-6 fruit (70%)
Bean	300-500	medium-high (1.15)	Lush: 1.5-2.0 (80-90%) dry: 0.3-0.6 (10%)
Cabbage	380-500	medium-low (0.95)	12-20 head (90-95%)
Citrus	900-1200	low to medium-high (0.8-1.1)	2-5 fruit (85%, lime: 70%)
Cotton	700-1300	medium-low (0.85)	0.4-0.6 seed cotton (10%)
Groundnut	500-700	Low (0.7)	0.6-0.8 unshelled dry nut (15%)
Maize	500-800	High (1.25)	0.8-1.6 grain (10-13%)
Potato	500-700	medium-high (1.1)	4-7 fresh tuber (70-75%)
Rice	350-700	high	0.7-1.1 paddy (15-20%)
Safflower	600-1200	Low (0.8)	0.2-0.5 seed (8-10%)
Sorghum	450-650	medium-low (0.9)	0.6-1.0 grain (12-15%)
Wheat	450-650	medium high (spring: 1.15; winter: 1.0)	0.8-1.0 grain (12-15%)

1. Flood irrigation is the process of saturating a land with water like wild flooding.
2. In a furrow irrigation system, water is applied between the ridges [16–18]. Capillary action draws water to the ridge, concentrating plant roots.
3. Sprinkler irrigation - water is sprayed over the earth, similar to rain like portable and solid set sprinklers. The pace of application is managed to avoid surface ponding.
4. Capillary rise transports water beneath the root zone (sub-irrigation) like subsurface irrigation canals. This is done via deep surface canals or underground tunnels.
5. Localized irrigation saturates only the root zone of each plant or group of plants like drip irrigation. Reduce percolation losses by adjusting the application rate to evapotranspiration needs.

The basic soils are clay, loam, and sandy soils, in addition to loamy soils, which are a mixture of all three basic soils; The concept of soil water retention lies in the fact that it is the water that the soil retains after passing through the soil pores to join water bodies such as groundwater or surface currents, and the pores in the soil can be defined as the air spaces between soil particles. Clay soil is one of the most common types [16, 19, 20]. Clay soil can hold water better than other types because it is characterized by the size of its pores and small particles that retain water. Still, it is exposed to the risk of waterlogging, and therefore it may not be suitable for growing all types of plants [21–23].

The main goal of determining the type of soil is to know the extent to which the soil retains the amount of water for a longer period, and the other purpose is to determine the type of soil so that some plant roots are exposed to damage because some plants cannot be planted in clay soils.

2.1. Distribution method

After collecting the readings for soil moisture and bulk filling Database attributes with the data, the penultimate stage of system implementation will begin comparing the soil moisture that was read with the type of plant being grown and the weather condition. It is the most critical stage in System implementation. The electronic irrigation process is done by applying the ANN method, in particular the Kohonen SOM algorithm. The system decides the process of starting irrigation by comparing the soil moisture with the type of planted plant. Suppose the amount of water required for the cultivated plant is less than the necessary need. In that case, the electronic irrigation process is done after comparing it with the weather since the irrigation process is not done in the case of a rainy process. So that the plant is not exposed to damage by implementing the Kohonen SOM algorithm according to the amount of cultivated area and the type of plant to be planted. The SOM of Kohonen is an effective method for unsupervised classification Fields due to its interesting and high quality. This is the famous method given in the Quantitative scaling vector framework for algorithms and the k-means algorithm method. More Accurately, SOM is an extension of Pattern Recognition and Automated classification algorithms. Kohonen's SOM Algorithm is unsupervised. Split classifier (that is, it deals with unranked entries and provides classes without overlap.

The unsupervised workbook collects information with the same features in a file a specific group and variants in other different groups lead to a lot of savings necessary time. By applying this algorithm to the training database of 50 readings, you learn its parameters (weights and learning rate) as in the algorithm steps shown below. In this total Sheet number of reads for an entire year, soil moisture readings were taken as input. The number of planted plants (groups) is determined, representing (6) plants in this paper. Also, the minimum to start with the electronic irrigation process Plant type was chosen as weights adapted. By implementing the steps of the algorithm, the minimum to create the electronic irrigation process is updated. Finally, the algorithm classifies electronic irrigation and controls the irrigation process. Using the training data, a database of (50) readings in the learning process predicts or estimates the correct outcome of any new entry created in the generalization process [21, 24]. The resulting neurons are considered to be clusters. In this paper, each group refers to a particular independent plant. Summarizing a text from Kohonen's SOM used the algorithm [10, 25] is described below.

Input: row data vectors (ranges of total scores of soil moisture readings) Output: clusters of classified and distributed data

- Initialize N of weight vectors
- Set topological neighbourhood parameters such as:
  1. Learning rate α where ($\alpha < 1$)
  2. Geometric schedule f for decreasing α where ($0 < f < 1$)
- Initialize input vectors X = V (i)
- Start iterations
- For each step (iteration) k= 1, 2, ... do, (step a - step d) by cycling through training set until weight vectors converge
  1. Set one of the training vectors input vector (X = V (i))
  2. For each cluster unit Z = 1,.., N where (no. of Z = no. of N vectors) do,
  3. Compute the Euclidean distance
  4. Indexing the computed distances by Z' to find the minimum dz'
  5. For all cluster units Z within the specified neighbourhoods of Z',
  6. Update the weight vectors
  7. Update learning rate α.
  8. At particular times, reduce the radius of the topological neighbourhood by a given amount: $\alpha(k+1) = \alpha(k) * f$
  9. End iterations when the map is converged

3. The irrigation system

The system is built using an electronic development board that combines an open-source electronic circuit with a microcontroller on one board. It can be used to quickly and easily make various ideas and projects connected to autonomous control. It was created to popularize electronic circuit design (Arduino). As shown in the flow chart Figure 1, the designed electronic irrigation system begins with determining the type of soil and then determining the type of plant grown.

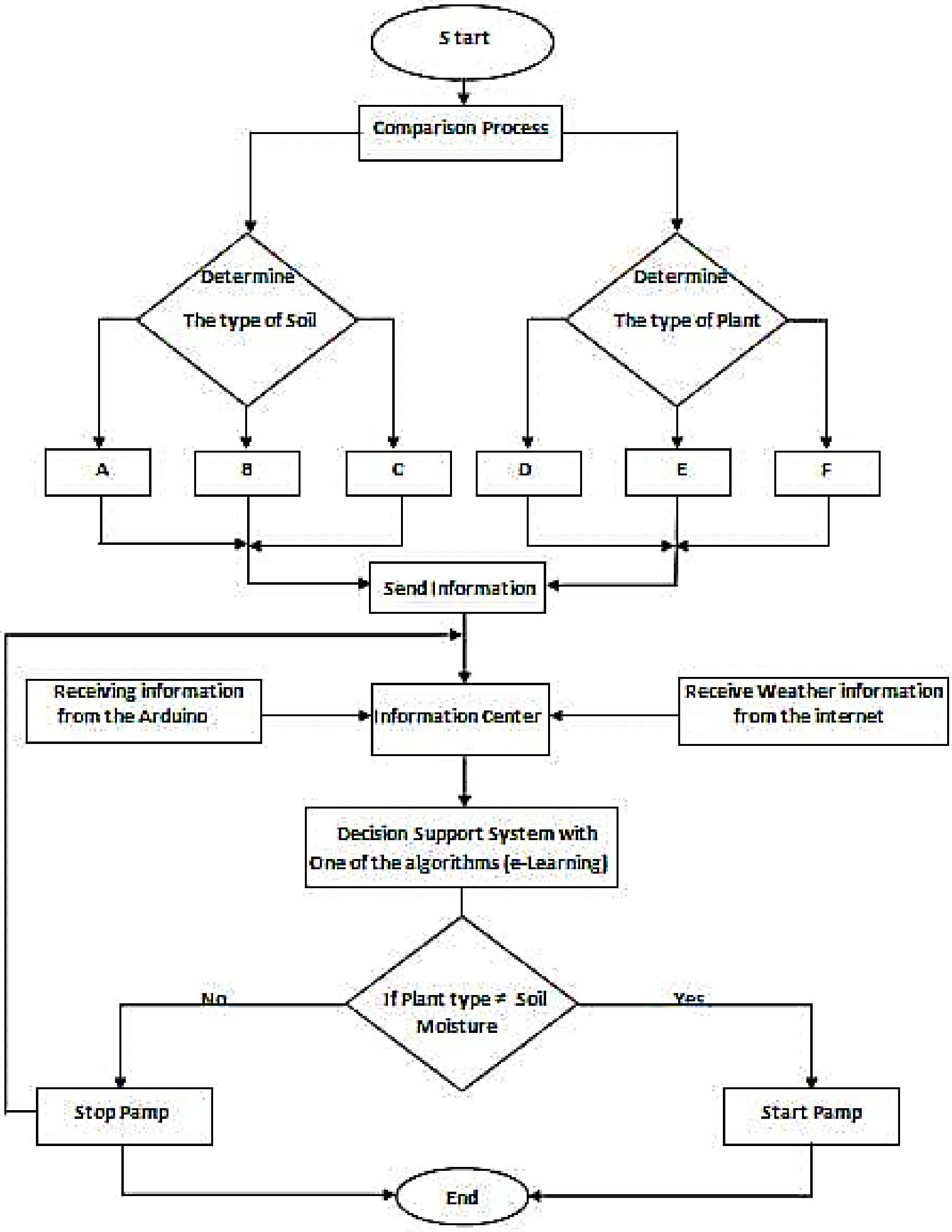

Figure 1. System flow chart

This critical step is to determine and control soil moisture according to the type of plant grown. In the second step, the system starts receiving sensors readings through soil moisture sensors (FS-28) and Rain Sensor Arduino, see Figure 2. Sensors are distributed to read the soil moisture on the cultivated ground. The read of the sensors will be sent to Arduino (ESP-8266), which will transfer it to a server. The classification process is performed in the third step, and the lowest soil moisture reading is selected. Based on the Kohonen Neural Networks (KNN) algorithm, the classification is used to sort the described irrigation planning strategies into minimum readings. Weather conditions are used to alert the system to avoid the plant being damaged by rain. The lowest reading of soil moisture is compared with the water needed by the plant, if it is quieter, watering is started, and otherwise, it is stopped.

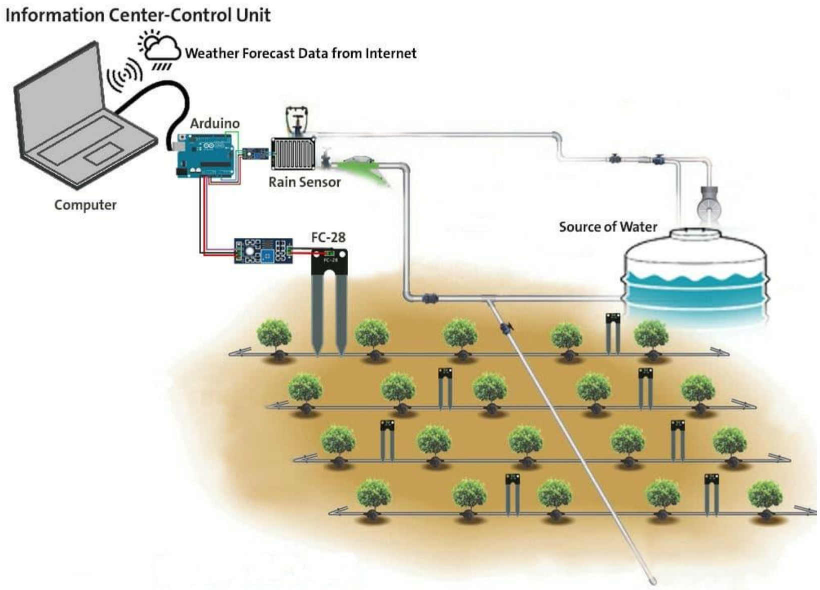

Figure 2. Mechanism of the irrigation system

A potentiometer is also included in the module, which will be used to set the threshold value. The LM393 comparator will compare the specified threshold value. This threshold value will cause the output LED to glow on and off.

For analog mode, We'll need to use the sensor's analogue output to connect the sensor in analogue mode. The soil moisture sensor FC-28 gives us a value between 0 and 1023. When we take the analogue output, we'll map these values from 0 to 100 and display them on the serial monitor because moisture is measured in percentages. Then you can choose from a variety of moisture value ranges.

4. Result and discussion

Due to rain's lack in recent years, electronic irrigation systems have increasingly been used to avoid water wasting. As a result, electronic systems that represent electronic irrigation are more effective than manual watering. Finally, the mentioned criteria in table 2 demonstrate the benefits of electronic irrigation and the design. Figure 3 shows that the system has very high standards for less water consumption than conventional manual irrigation. Moreover, plant damage is significantly reduced. This system appears to reduce the number of workers of the traditional approach and reduces the cost.

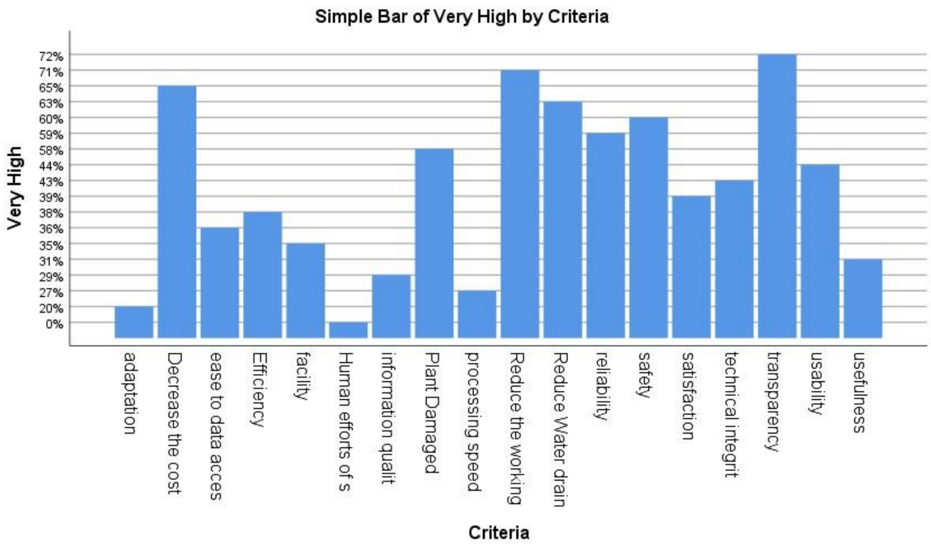

Figure 3. Very high criteria

The system has proven its high standards as shown in Figure 4 in the high processing speed and the quality of the information, and the great benefit of the system.

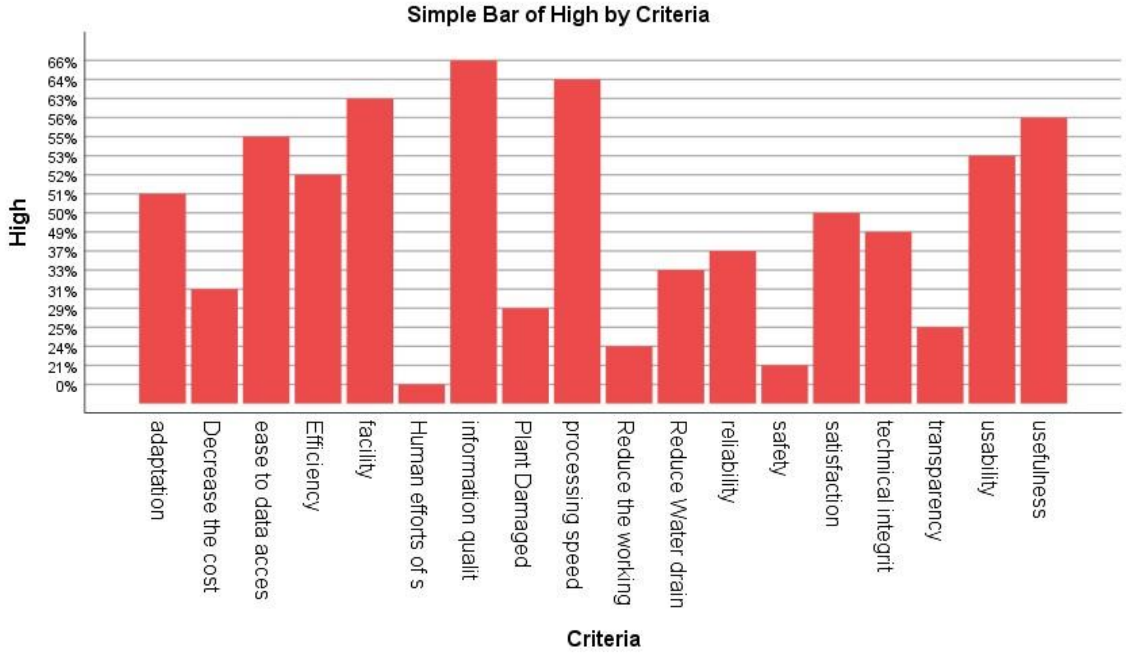

Figure 4. High criteria

The system has proven its Moderate standards, as shown in Figure 5. The bar indicates how to meet the high requirements of the system; in addition, it reduces the efforts of the human system and the ease of accessing the data.

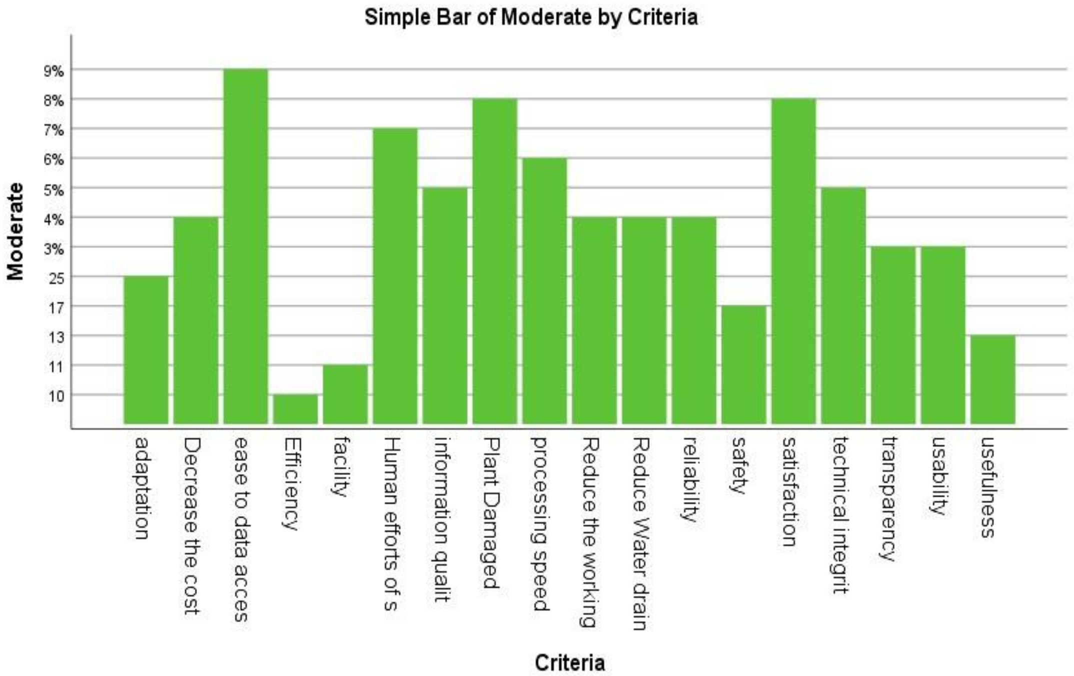

Figure 5. Moderate criteria

It has been proven that the system standards are low and very low, as shown in Figures 6 and 7. The bars show how the system is safe and easy to use and that satisfaction by the users.

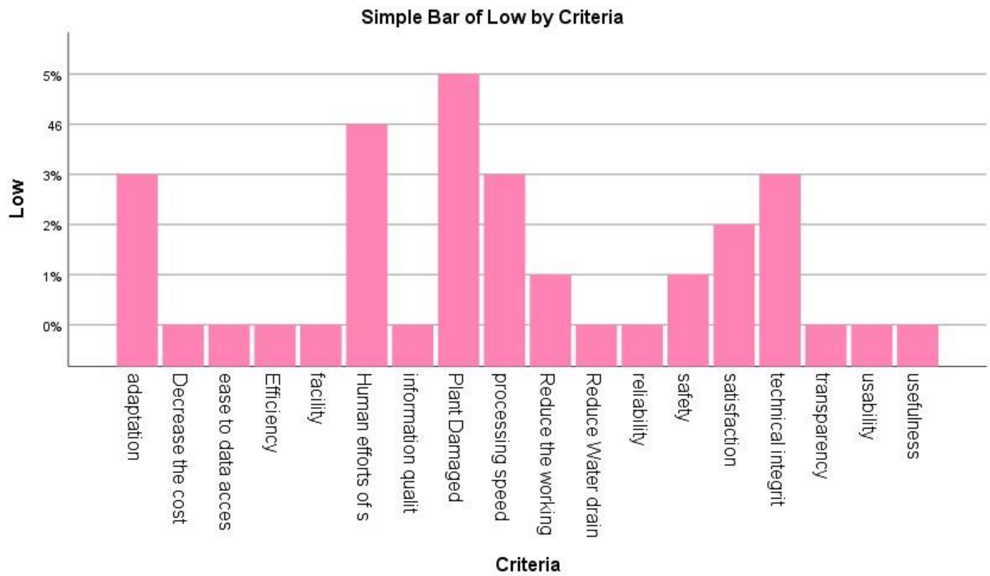

Figure 6. Low criteria

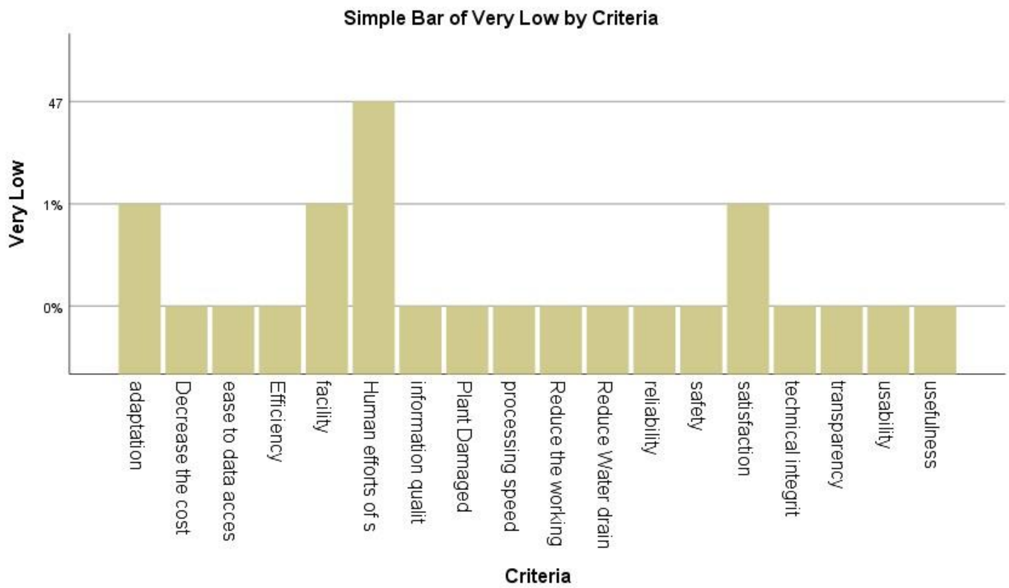

Figure 7. Very low criteria

Table 2. System evaluation

Criteria	Very High	High	Moderate	Low	Very Low
Reduce Water drain	63%	33%	4%	0%	0%
Plant Damaged	58%	29%	8%	5%	0%
Reduce the working people	71%	24%	4%	1%	0%
Decrease the cost	65%	31%	4%	0%	0%
usability	44%	53%	3%	0%	0%
Efficiency	38%	52%	10%	0%	0%
usefulness	31%	56%	13%	0%	0%

facility	35%	63%	11%	0%	1%
processing speed	27%	64%	6%	3%	0%
ease to data access	36%	55%	9%	0%	0%
information quality	29%	66%	5%	0%	0%
reliability	59%	37%	4%	0%	0%
safety	60%	21%	17%	1%	0%
adaptation	20%	51%	25%	3%	1%
satisfaction	39%	50%	8%	2%	1%
technical integrity	43%	49%	5%	3%	0%
Human efforts of system	0%	0%	7%	46%	47%
transparency	72%	25%	3%	0%	0%

5. Conclusion

Due to the dry and semi-arid climate, water resources have become scarce, indicating that a water crisis coincides with population growth, increased demand for water, restricted availability, and diminished supplies due to drought. As a result, the integrated notion of improving irrigation systems and rationalizing water use must be prioritized. By implementing the electronic irrigation system, we concluded the following: Improve irrigation water management, reduce plant damage by irrigating plants according to their needs in terms of water quantity, and compare irrigation with climatic conditions to prevent plant damage and minimize labour. The artificial neural network system is used in the system to increase processing and decision-making speed. The potential of Kohonen Neural Networks was used as a classification tool in choosing the lowest moisture reading of the soil in cultivated areas and the need for irrigation. Also, it is concluded the adaption of the system to all climatic conditions and all types of soil.

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